

CARBON AND SILICON NANOWIRE CHEMICAL SENSORS FOR IN SITU ASTROBIOLOGICAL MEASUREMENTS*. Brian Hunt, Mike Bronikowski, Anita Fisher, and Eric Wong, NASA/JPL/Caltech, Pasadena, CA 91109, bdhunt@jpl.nasa.gov.

Nanowire-based chemical sensors utilize a simple and effective sensing mechanism based on the change in conductance of a semiconducting nanowire (NW) as a molecule adsorbs on the surface of the wire. These devices act as chemically sensitive field-effect transistors (FETs) in which conductance changes arise from electrostatic gating or charge transfer from attached molecules. Such sensors have already demonstrated detection limits in the picomolar to femptomolar range for a few model molecular systems [Hahn and Lieber, *Nano Letters* **4**, 51 (2004)]. The nanowire molecular sensors typically operate at sub-nW power levels and can be made chemically specific by functionalization of the nanowire surface, as illustrated in Figure 1.

Here we report on our work on nanowire chemical sensors utilizing carbon nanotubes (CNT) and silicon nanowires grown by chemical vapor deposition (CVD) from nanoscale catalyst particles. The CNT devices are produced using lithographically patterned molybdenum electrodes followed by definition of an iron nanoparticle catalyst region and CVD growth of the nanotubes, resulting in single-wall nanotubes spanning electrode gaps ranging from 100 nm to 2 microns (Figure 2). The Si NW are grown from Au nanoparticle catalysts or nm-thickness Au films, followed by patterning of Ti/Au electrodes. To date, our chemical sensing efforts have focused on bare, unfunctionalized nanowires, primarily CNTs. We have demonstrated both gas and liquid phase chemical sensing using the CNT devices. The liquid phase testing has been aimed at measurements of amino acids in water, as key molecules of interest in astrobiology. Preliminary conductance-versus-time measurements of electrically gated nanotube sensors were made as the concentrations of three different amino acid solutions were varied. These experiments showed clear differences in the conductance change for arginine, aspartic acid, and tryptophan. Further studies are underway to optimize the sensitivity via adjustment of the device gate voltage and to understand the effect of pH. These initial measurements suggest that even unfunctionalized nanotubes may be useful for amino acid sensing. We will also report on our ongoing efforts to functionalize Si/SiO₂ and CNT surfaces to enable chemically specific detection of biomolecules of interest. The initial functionalization studies have utilized oxysilane chemical linkers on Si/SiO₂ to attach biotin as a model receptor. Chemically specific reaction with the model target molecule, streptavidin labeled with Au nanoparticles, was verified by AFM and SEM studies. Such functionalization may eventually enable chemically specific sensing of a variety of different molecules in nanowire sensor arrays, as well as chirally specific sensing of biomolecules as a potential indicator of extraterrestrial life. **Work supported by NASA Code R/T BioNano program.*

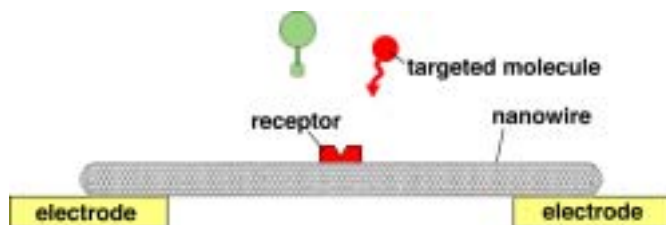


Figure 1. Schematic illustration of chemical sensor using functionalized CNT and conductance modulation.

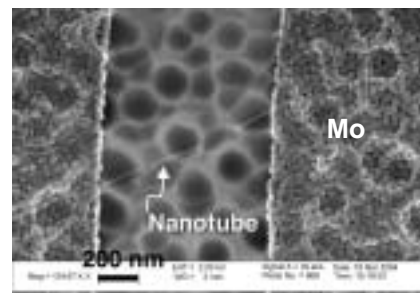


Figure 2. SEM picture of CNT bridging gap between Mo electrodes.